Lesson 4
Explain
Elaborate

Individual Responses Can Be Different

At a Glance

Overview

Students are aware after Lesson 3 that not all chemicals have the same effect on seed germination. In this lesson, students look at the variation among responses of seeds to the same dose of the same chemical. In reviewing their seed investigation, students note that sometimes not all seeds in the same bag responded in the same way. Students then use information about acetaminophen to learn more about dose and individual susceptibility. They learn that individual variability accounts for the different responses in the same types of organisms exposed to the same dose of a chemical. Students conduct an investigation into their own susceptibility to caffeine and compare individual responses.

Major Concepts

The variety of responses among organisms exposed to the same dose of chemical is due to individual susceptibility. Dose and individual susceptibility play roles in all situations involving chemicals, including those involving medicines and caffeine.

Objectives

After completing this lesson, students will

- understand that the variety of responses among seeds exposed to the same dose of chemical is due to individual susceptibility and
- recognize that dose and individual susceptibility play roles in human exposure to chemicals, such as drugs and caffeine.

Background Information

Toxic Effects of Chemicals

The human body is a complex organism. It responds to both external and internal conditions. For example, when the body gets too hot, it begins to cool itself by turning on its cooling system: sweat. When sensors in the brain detect that the body has cooled enough, the brain turns off the sweat glands.

Sometimes the body's balance is upset by chemical agents that put stress on different body functions. Some chemicals increase heart rate or sweating. Others decrease the rate of breathing. A chemical can have a wide-ranging effect or it can cause a very limited change in a particular organ of the body. A chemical is toxic if the body's response to it is an adverse one, such as headaches, nausea, rashes, convulsions, or death.

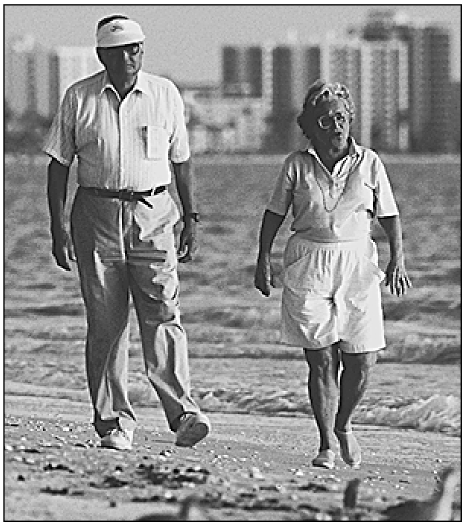
Chemicals vary widely in their toxic potential. The variation among chemicals is due to their chemical structure. A chemical's structure determines

- how the chemical is metabolized,
- the rate at which it is absorbed, and
- how it is excreted.

Small differences in structure can cause big differences in toxicity.[1]

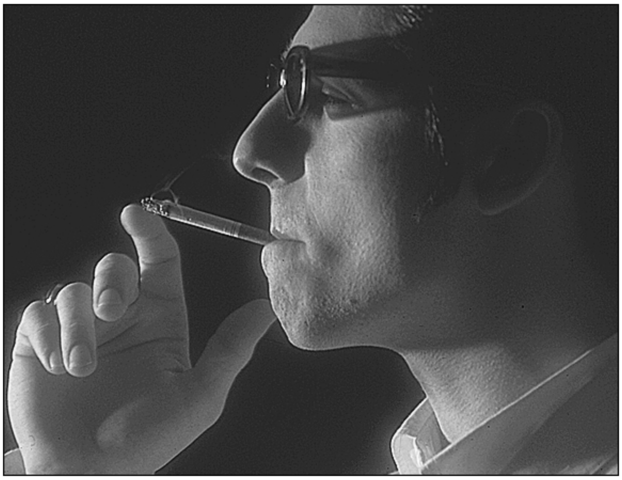
Individual Susceptibility

The effect of a chemical also depends on another set of variables. Organisms will have various responses to chemical exposures because each organism is unique. For example, if a population of people was exposed to the same amount of the same chemical, some people might have very severe reactions to the chemical while others might have no reaction at all. Those with a severe reaction are considered more “susceptible” to the chemical. Individual susceptibility varies but is influenced by age, gender, health status, genetics, and lifestyle.



Photos: Corel

Children and elderly people often have an increased susceptibility to chemicals. For example, children have higher rates of respiration and consume more calories per unit of body weight than adults do. This can result in a greater exposure to and dose of a chemical for children compared with adults. The metabolism of chemicals also can vary because children’s metabolic systems are still developing. In contrast, changes in physiologic functions, such as diminished kidney function, can impair the ability to excrete chemicals in an elderly person.



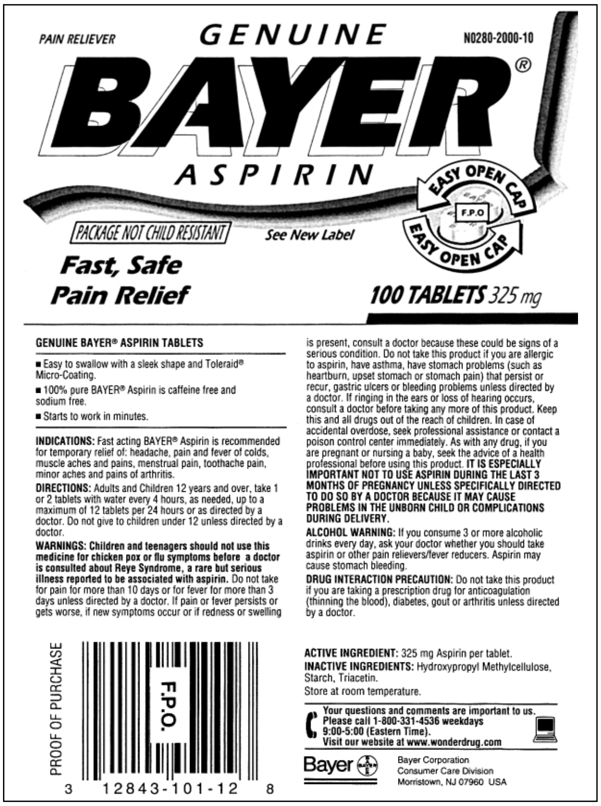
Photos: Corel

Some people's susceptibility is related to their overall health. People with asthma may be more susceptible to air pollution. Lifestyle factors such as smoking, drinking, and drug use may affect a person's susceptibility to toxicants. On the other hand, people with good nutrition and health are more resilient, so they can metabolize and excrete toxic substances faster.

Chemicals sometimes affect males and females differently. For example, women absorb and metabolize alcohol differently from men. Women will generally have a higher blood alcohol concentration after ingesting the same amount of alcohol as men. While some of the difference in blood alcohol concentration can be attributed to the difference in size between men and women, scientists also have found that women have less active enzymes that metabolize alcohol, causing a larger proportion of the ingested alcohol to reach the blood.[2] When drinking heavily, women are more susceptible to alcoholic liver disease, heart muscle damage, and brain damage. In addition, pregnant women can share an exposure to a chemical with the fetus through the placenta, and women who are nursing may expose their babies to the chemical through breast milk.

Inherited differences among people account for some of the different ways people respond to chemicals. For example, some people are genetically more susceptible to poisoning from the insecticide parathion. Most commonly, people are exposed to parathion by eating foods grown with the use of the insecticide. Differences in individual reactions to the chemical depend on which of the two variants, or alleles, of a particular gene the individual carries. One variant results in low activity of the enzyme paraoxanase, and one variant results in high activity of the enzyme. Scientists have determined that the enzyme paraoxanase breaks down parathion into inactive, nontoxic products that are excreted in the urine. Those people who have the highly active enzyme and are exposed to parathion have mild symptoms such as abdominal discomfort, vomiting, and diarrhea, followed by headache and weakness, because their bodies are able to break down the parathion into nontoxic products at a higher rate. Those people with the gene that results in low activity of the enzyme can have much more severe symptoms when exposed to the same amount of parathion. These people may experience sudden collapse, coma, sweating, and difficulty breathing because their bodies cannot break down parathion quickly and the chemical remains in the body for a longer time.

Understanding the variety of responses that different individuals can have to different doses of a chemical is important to the study of pharmaceuticals. Written on the label of any drug are indications describing who can use the drug and how much to take. In addition, warning statements



Courtesy of the Bayer Corporation

describe who should not use the drug. Such information is the result of the knowledge scientists have gained about the way the chemical affects a diverse population over time.

The Chemical Caffeine

Caffeine is a chemical that most people ingest at some time in their lives, and many people ingest caffeine daily. People consume caffeine in coffee, tea, cocoa, chocolate, soft drinks, and some drugs. It is a naturally occurring chemical that comes from the coffee bean, tea leaf, kola nut, and cacao pod.

Photos: Corel

As a central nervous system stimulant, caffeine in moderate doses can increase alertness, reduce fine motor coordination, alter sleep patterns, and cause headache, nervousness, and dizziness. In massive doses, caffeine is lethal. However, it is hard to get a lethal dose of caffeine just by ingesting it in food and drink: A lethal dose of caffeine is 170 milligrams of caffeine for every kilogram of body weight, or about 10 grams for an average-sized adult. One would have to drink 80-100 cups of coffee in rapid succession to reach that threshold.[3]

Caffeine is absorbed rapidly into the bloodstream from the gastrointestinal tract. It can exert its effects within 15 minutes after it is consumed and reaches maximum concentration in the bloodstream within about one hour. The blood distributes caffeine throughout the body, where the caffeine increases metabolic rate by about 10 percent. Once in the body, caffeine will stay around for hours: It takes about six hours for one-half of the caffeine to be eliminated. Gender affects a person's response to caffeine: Females metabolize caffeine 20–30 percent more quickly than do males.[4]

Because caffeine constricts the cerebral blood vessels, blood pressure rises and heart rate increases in the presence of caffeine. When people who regularly ingest caffeine stop ingesting it, they can suffer severe headaches because the blood vessels in their brain are dilating.

Research into the detrimental effects of caffeine has not uncovered any connections between ingestion of caffeine and heart disease, stroke, or cancer. There are some studies that show that large doses of caffeine, such as five to seven cups of coffee a day, can delay fertility.[5]

Many soft drinks popular among youth contain caffeine. The following table lists some soft drinks (12-ounce size) and the amounts of caffeine they contain.

Amount of Caffeine in Soft Drinks

Soft Drink	Milligrams in 12 ounces
Jolt Cola	71 mg
Josta	58 mg
Mountain Dew	55 mg
Surge	51 mg
Diet Coke	45 mg
Coca-Cola	45 mg
Dr Pepper	41 mg
Sunkist Orange Soda	40 mg
Pepsi Cola	37 mg
Barqs Root Beer	23 mg
7-Up	0 mg
Minute Maid Orange Soda	0 mg
Mug Root Beer	0 mg

Source: Center for Science in the Public Interest. Soft drinks and health: Caffeine content of foods and drugs. Retrieved August 17, 2000 from the World Wide Web: *www.cspinet.org/new/cafchart.htm.*

Compared with other drinks popular with adults, the caffeine content in soft drinks is lower. Coffee can contain between 80 and 175 milligrams of caffeine (per 7 ounces) depending on how it is brewed; espresso has 100 milligrams in just 1.5 to 2.0 ounces. Tea can contain 40–60 milligrams of caffeine (per 7 ounces). Ice tea contains 70 milligrams of caffeine in 12 ounces.

Notes About Lesson 4

In this lesson, students can use information from their seed investigation to help them understand some of their own voluntary exposures to chemicals. When they take a medicine, they are exposing themselves to a chemical. When they follow the correct dosage for that medicine, they are taking advantage of what scientists know about how much exposure to the chemical results in the desired response. In addition, although they might not think of it in these terms, students are exposing themselves to the chemical caffeine each time they drink a caffeinated soft drink or eat a piece of chocolate. Students intuitively know that caffeine, a stimulant, affects some people more than others: It may keep some people awake at night while others can drink a caffeinated drink right before bedtime and still sleep. In this lesson, students measure their own heart rates after drinking a soft drink containing caffeine to see if they can quantify some of those individual differences.

In Advance

CD-ROM Activities	
Activity Number	**CD-ROM**
Activity 1	no
Activity 2	yes
Activity 3	no
Extension Activity	no

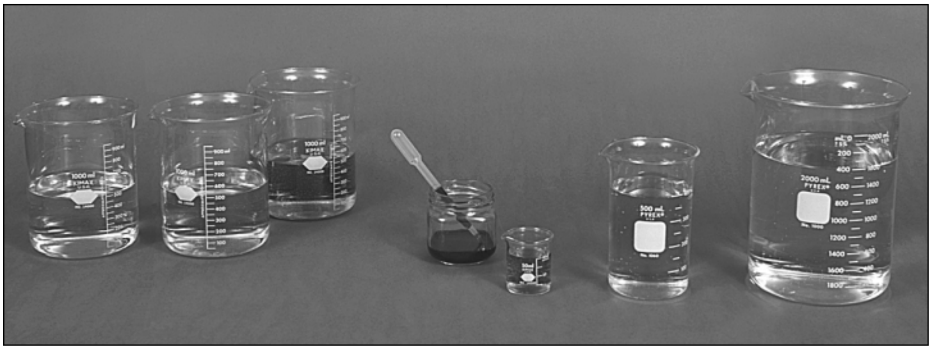
Photocopies		
Activity Number	**Master Number**	**Number of Copies**
Activity 1	Master 4.1, *Acetaminophen Dosage Chart*	1 transparency
Activity 2	Master 4.2, *A Poisonous Dose? The Case History* Master 4.3, *A Poisonous Dose? The Problem*	1 2-page transparency (optional) 1 for each student (optional)
Activity 3	Master 4.4, *Parent Letter* Master 4.5, *The Chemical Caffeine: How Do You Respond?*	1 for each student 1 for each student
Extension Activity	none	none

Materials	
Activity 1	
For the class: • overhead projector • transparency of Master 4.1, *Acetaminophen Dosage Chart* • overhead markers • 3 large beakers filled with equal amounts of water and drops of mystery chemical from Lesson 2, Activity 1	• 3 clear containers of distinctly different sizes, each filled with distinctly different amounts of water, labeled #1, #2, #3 • jar of mystery chemical from Lessons 1 and 2 • eyedropper **For each student:** • science notebook with seed investigation data table • pencil
Activity 2	
For the class: • CD-ROM • computers • overhead projector • transparency of Master 4.2, *A Poisonous Dose? The Case History* (optional)	**For each student:** 1 copy of Master 4.3, *A Poisonous Dose? The Problem* (optional)
Activity 3	
For the class: • clock with a second hand **For each student:** • 1 12-ounce can of caffeinated soft drink, or equivalent amount of water	• 1 copy of Master 4.4, *Parent Letter* • 1 copy of Master 4.5, *The Chemical Caffeine: How Do You Respond?* • pencil
Extension Activity	
• none	

PREPARATION

Activity 1

If necessary, fill the 3 beakers from Lesson 2 with equal amounts of water. Add 1 drop of the mystery chemical to Beaker #1, 4 drops to Beaker #2, and 16 drops to Beaker #3.



Collect 3 clear containers of different sizes and label them #1, #2, and #3. Fill each container with water, making sure that each container holds obviously different amounts of water, with #1 having the least and #3 having the most.

Make a transparency of Master 4.1, *Acetaminophen Dosage Chart*.

Activity 2
Decide whether you will use the CD-ROM or print version of this activity. If you choose the CD-ROM version, arrange for students to have access to computers.

If you use the print version, conduct the activity with the whole class. Later, let students review the problem using the CD-ROM on their own at a computer center. Make a transparency of Master 4.2, *A Poisonous Dose? The Case History*. Duplicate Master 4.3, *A Poisonous Dose? The Problem*, 1 for each student.

Activity 3
At least one week before conducting Activity 3, send home personalized parent letters (Master 4.4, *Parent Letter*) to inform parents of the investigation and to get permission for the students to consume a caffeinated soft drink during science class. You can use the letter to ask each student to bring in his or her own can of the designated caffeinated soft drink.

Arrange to have enough cans of the same kind of caffeinated soft drink for each student who participates in the investigation. There are several ways to do this:

- purchase all the soft drinks yourself through your school budget,
- ask for parent or business donations to cover the cost, or
- request that each student bring in one can of the same kind of soft drink, labeled with his or her name, for his or her consumption only.

Before the day of Activity 3, have students practice taking a resting heart rate so they are used to finding their pulse, counting the beats for 15 seconds, and multiplying the number they count by four to get a resting heart rate for one minute (see Activity 3).

Duplicate Master 4.5, *The Chemical Caffeine: How Do You Respond?*, 1 for each student.

Procedure

ACTIVITY 1: DIFFERENT DOSES FOR DIFFERENT PEOPLE

1. **Ask students why they think toxicologists look at both whether a chemical has an effect on living things and what happens at different doses. Why do students think it matters to look at doses?**

   Students may bring up the term *overdose*, which refers to a situation in which a person receives too much of a particular chemical, usually a drug. Students should realize that the proper dose of a chemical is what makes it beneficial to people and that knowing the dose is useful in determining the appropriate human consumption of that chemical. Some chemicals, such as vitamins and minerals, are beneficial at a particular dose, but human health suffers if the chemicals are present in high or very low doses (you can have too much or not enough). Other chemicals, such as drugs and pesticides, usually are more harmful as the dose increases.

2. Tell students that you are going to demonstrate one reason why paying attention to dose is important in the study of toxicology.

- **First, on one side of a desk at the front of the room, place the three large beakers filled with equal amounts of water and different amounts of mystery chemical from the demonstration in Lesson 2. Remind students that this is the demonstration they saw before they began their seed investigation.**
- **Then, place three different-sized clear containers on the desk. Fill each container with water, making sure that it is obvious that each container holds a different amount of water (#1 holds the least and #3 holds the most).**
- **Using the eyedropper from Lesson 1, place two drops of mystery chemical in each of the containers. Swirl the containers to mix the chemical and the water.**

3. Ask students to observe the three new containers and compare them with the setup of the demonstration from Lesson 2. Discuss their observations by asking questions like these:

- **Is this new demonstration the same as the one I did for you before you began your seed investigation? Why or why not?**

Students will recognize that the demonstration is different. Today, you are using different-sized containers (and different amounts of water) and the same amount of chemical; earlier you used the same size containers and different amounts of chemical.

Content Standard A: Students think critically and logically to make the relationships between evidence and explanations.

- **What was the variable in the earlier demonstration?**

The variable was the amount of chemical you added to each beaker of water. The dose was the variable. The amount of water was the constant.

- **What is the variable I am using today?**

Today, the variable is the amount of liquid in each container. The dose of chemical is a constant.

- **How would you describe the concentrations of chemicals in each of the containers in today's demonstration?**

The concentration of chemical in each container is different in today's demonstration because the amount of water in each container is different although the amount of chemical is the same. Because concentration is a measurement of the amount of chemical compared with the volume of water, the concentration of chemical in Container #1 is higher than the concentration in #2 or #3.

- **What do you think the containers in today's demonstration are illustrating? Why do you think it matters that the containers are different sizes?**

The different-sized containers represent the different variations in size of people who might be exposed to the mystery chemical. In smaller people (Container #1), 2 drops of chemical result in a higher concentration of chemical in their bodies than do 2 drops in either of the larger people (Containers #2 and #3). This higher concentration could be beneficial (if it approaches the threshold that creates beneficial results) or it could be harmful (if the higher concentration exceeds the threshold for safe use of the chemical).

- **When might understanding this relationship of dose to size matter?**

When people use drugs to treat illness, they are exposing themselves to chemicals. To understand how much of a chemical is needed to get the desired effect, such as lowering fever or reducing pain, you need to understand that the same dose of chemical will have different effects on different-sized people because it results in different concentrations in their bodies.

Tip from the field test: This is a simple demonstration that, when coupled with students' understanding of the earlier demonstration, moves students to use the language of toxicology: dose, response, concentration.

Ask students to write about the two demonstrations and clearly discuss what is different about the two.

4. **Keep the containers of water on the desk while you display the transparency of Master 4.1 *Acetaminophen Dosage Chart*. Ask questions such as these to discuss the concept of dose with respect to body size:**

- **What is acetaminophen?**

Students might need you to tell them that acetaminophen is the active ingredient in Tylenol products. It is a chemical that, when taken into the human body, elevates the pain threshold and reduces fever.

- **For all people, what is the response they want to get from exposure to a dose of acetaminophen?**

They want to reduce their fever or pain.

- **What does the dosage chart tell you about the relationship between dose and body size?**

The dose increases as the body size of the individual increases. Students can see from the chart that each tablet of Children's Chewable Acetaminophen provides a dose of 80 milligrams of acetaminophen. As a child grows, the amount of acetaminophen needed to reduce fever and pain increases. For example, a child weighing 40 pounds needs a dose of three tablets at 80 milligrams of acetaminophen per tablet, or 240 milligrams of medicine. A child weighing 80 pounds needs six tablets at 80 milligrams each, or a dose of 480 milligrams of acetaminophen.

Tip from the field test: Use this time to teach students how to read a dosage chart. Show them where to find information about the number of milligrams of acetaminophen each measurement contains (for example, one tablet contains 80 milligrams of acetaminophen). Impress upon them the importance of knowing a person's size (weight) to determine correct dosage. Familiarity with dosage charts makes it easier for students to work the problem in Activity 2.

Dosage is determined by body weight. Age is not an accurate measure for dose, but is included on many charts in case weight is unknown.

Dose is expressed in number of tablets (or capsules, teaspoons, or droppers).

Children's Chewable Acetaminophen*

Weight (lb)	Weight (kg)	Age (yr)	Dose
under 24	under 11	under 2	consult doctor
24–35	11–16	2–3	2 tablets
36–47	17–21	4–5	3 tablets
48–59	22–27	6–8	4 tablets
60–71	28–32	9–10	5 tablets
72–95	33–43	11	6 tablets

*1 tablet = 80 milligrams

Warning: Take no more than five doses per day.

Dosage charts always include information about milligrams per unit of measure.

- **Look again at today's demonstration. Which size child from the chart might each container in today's demonstration represent?**

Container #1 represents the smallest child, #2 a medium-sized child, and #3 the largest child.

- **If the 2-drop dose the smallest child received in Container #1 was correct for the child's size, what can you say about the dose the other two children received?**

The concentration of chemical in the larger children's bodies would be lower and might not be enough to provide the desired effect.

- **If the 2-drop dose in Container #3 resulted in a toxic response for the largest child, what can you say about the dose for the two smaller children?**

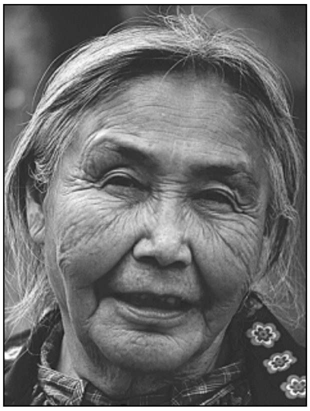
The dose for the two smaller children most would almost certainly be toxic because the concentration of chemical in their bodies is higher.

Content Standard F: Students should develop understanding of personal health.

5. Tell the students that size is one difference in people that can effect how susceptible they are to chemicals. Ask students what other factors about an individual might make the individual more or less susceptible to chemicals such as acetaminophen. List the factors on the board.

Start the list with size (weight). Other factors that can affect susceptibility to chemicals are age, lifestyle or behavior (such as being an alcoholic), gender, genetics, and general health.

6. Tell students that toxicologists know that these variable factors determine an individual's susceptibility to the effects of environmental toxicants. Write *individual susceptibility* as the title of the list you made on the board in Step 5. Tell students that, because of their understanding of individual susceptibility, toxicologists expect that individuals may respond differently to the same dose of a chemical.



Photos: Corel

7. Ask students to apply the concept of individual susceptibility to their observations of the seeds in their investigation. If students need help, prompt them with questions such as these:

- **Did all of the seeds in each of your bags respond to their dose of chemical in the same way?**

Answers will vary, but most likely students will have had bags in which not all of the seeds reached the same stage of germination by Day 3.

- **What factors in the seeds might account for the differences in germination among them?**

Seeds are processed from many different plants, so the genetic makeup might not be exactly the same among 10 seeds. Age might be a factor because some seeds might be older than other seeds. General health of the seeds could be a factor because some seeds might be less healthy than other seeds.

- **Why did you use 10 seeds to test each of the concentrations of chemical?**

By using 10 seeds, you can compensate for possible responses due only to individual susceptibility by observing the response in the majority of the seeds. If you tested only one seed, you wouldn't know if the response you observed was due only to the dose of the chemical or was a reflection of the seed's individual susceptibility to the chemical.

ACTIVITY 2: A POISONOUS DOSE?

The following procedures describe how to conduct the CD-ROM version of this activity, which is the preferred method of instruction. Instructions for the print version follow.

Use a computer lab where you can set up multiple computers. Insert the CD into the computer and pull up the main menu screen. Select *Individual Responses Can Be Different.* Start the activity by watching the video. Encourage students to work in pairs to solve the problem.

Print Version

If your students do not have access to computers equipped with a CD-ROM drive or you would like an opportunity to assess students individually on their understanding of a toxicology problem involving humans, use the following print version of Activity 2.

1. **Display the first page of the transparency you made from Master 4.2, *A Poisonous Dose? The Case History*. Read the transparency with the students.**

2. **Distribute copies of the first page of Master 4.3, *A Poisonous Dose? The Problem.* Ask students to work in teams of three to complete Part I. Circulate around the room to help students read the dosage chart, understand the math, and draw some conclusions.**

   Students should select letter **e**: Both b and d are correct. Andy received 1 teaspoon four times a day, or 4 teaspoons in all. Because there are 6.25 dropperfuls of acetaminophen in each teaspoon and 80 milligrams of acetaminophen in each dropper, the calculation of the amount of acetaminophen Andy received from his aunt should read:

$$4 \text{ teaspoons} \times \frac{6.25 \text{ dropperfuls}}{1 \text{ teaspoon}} \times \frac{\mathbf{80} \text{ milligrams}}{1 \text{ dropperful}} = \mathbf{2000} \text{ milligrams of acetaminophen}$$

The calculation of the maximum number of milligrams a child Andy's size should receive should read:

$$5 \text{ doses} = 10 \text{ dropperfuls} \times \frac{\mathbf{80} \text{ milligrams}}{1 \text{ dropperful}} = \mathbf{800} \text{ milligrams of acetaminophen}$$

As students work through the math, they see that the dose of acetaminophen the aunt gave Andy is much higher than the recommended maximum dose. Students can hypothesize, based on their understanding of dose and concentration and its relationship to size, that Andy was sick from too much acetaminophen.

3. **Distribute copies of the second page of Master 4.3, *A Poisonous Dose? The Problem.* Instruct students to continue to work in their teams of three to complete Part II up to the conclusion. Then ask students to work individually on the conclusion by writing about how they think the accidental overdose of acetaminophen happened.**

The calculation of the amount of acetaminophen in four doses of Children's Suspension Liquid should read:

$$4 \text{ doses} = 4 \text{ teaspoons} \times \frac{\mathbf{160} \text{ milligrams}}{1 \text{ teaspoon}} = \mathbf{640} \text{ milligrams of acetaminophen}$$

Content Standard A: Use mathematics in all aspects of scientific inquiry.
Content Standard E: Students should develop understandings about science and technology. Technological solutions have intended benefits and unintended consequences. Some consequences can be predicted, others cannot.

Andy's mother uses **a teaspoon** to measure a dose of Children's Suspension liquid. Andy's aunt used **a teaspoon** to measure Infants' Concentrated Suspension Drops. The dosage chart says to use **a dropper** to measure infants' drops.

Students can conclude that incorrect amounts of acetaminophen were given to Andy because his aunt did not understand that the acetaminophen in infants' formula is concentrated: It cannot be measured using the same units (teaspoons) as the children's formula. In fact, a teaspoon of infants' formula is more than three times stronger than a teaspoon of children's formula. Instead of teaspoons, infants' formula should be measured in droppers, which is indicated on the dosage chart. Unfortunately, the similarity in the appearance of the two liquids leads parents, care givers, and even doctors to believe that the two medicines are interchangeable.

Collect students' written conclusions of what happened to Andy. Assess students' writing for understanding of the roles dose and concentration played in Andy's overdose and how the confusion over the two kinds of acetaminophen led to the problem.

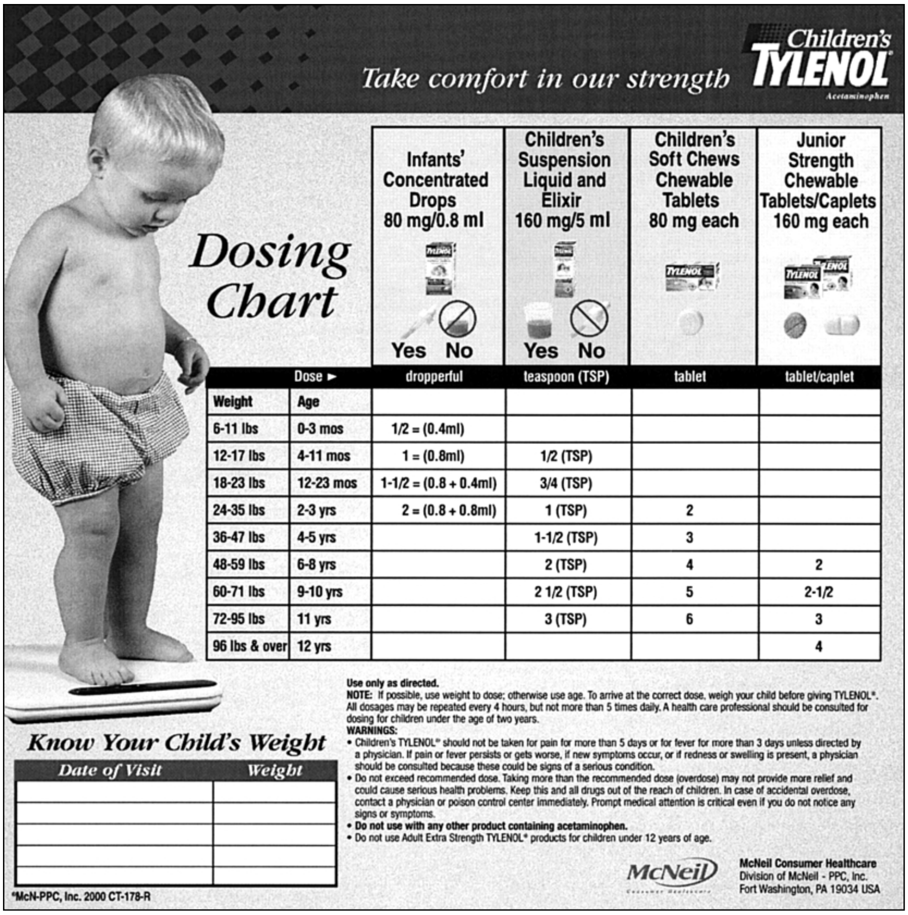
Students may ask why the infants' formula is stronger, when medicine formulas usually get stronger for people only as their body size gets bigger. Because it is so difficult to give medicine to a baby, it is important to pack as much acetaminophen as possible into the smallest volume of liquid. The higher concentration of the acetaminophen in infants' formula ensures that parents can administer the appropriate amount of medicine with the least amount of trouble.

4. **Display the second page of the transparency you made from Master 4.2, *A Poisonous Dose? The Case History*. Review with students the diagnosis and treatment.**

The doctor handling Andy's case had seen severe liver damage and even death from liver failure among children who experienced accidental acetaminophen poisoning. She knew that an overdose of acetaminophen is 150 milligrams for each kilogram of body weight. For Andy, who weighs 12 kilograms, an overdose would be 1,800 milligrams. In Part I, students calculated that Andy received 2,000 milligrams of acetaminophen, clearly an overdose. The doctor administered an antidote (n-acetylcysteine) within 8 to 12 hours of the poisoning and the boy recovered.

5. **Ask students how they think a mistake like the one that poisoned Andy could be avoided.**

   Because of situations like Andy's, changes in the labels and inserted instructions for acetaminophen products now inform people of the potential dangers of taking too much acetaminophen and more clearly describe appropriate dosage. Adults are reminded to use the dropper for the infants' formula acetaminophen, which is the appropriate unit of measure.



		Infants' Concentrated Drops 80 mg/0.8 ml	Children's Suspension Liquid and Elixir 160 mg/5 ml	Children's Soft Chews Chewable Tablets 80 mg each	Junior Strength Chewable Tablets/Caplets 160 mg each
	Dose ►	dropperful	teaspoon (TSP)	tablet	tablet/caplet
Weight	Age				
6-11 lbs	0-3 mos	1/2 = (0.4ml)			
12-17 lbs	4-11 mos	1 = (0.8ml)	1/2 (TSP)		
18-23 lbs	12-23 mos	1-1/2 = (0.8 + 0.4ml)	3/4 (TSP)		
24-35 lbs	2-3 yrs	2 = (0.8 + 0.8ml)	1 (TSP)	2	
36-47 lbs	4-5 yrs		1-1/2 (TSP)	3	
48-59 lbs	6-8 yrs		2 (TSP)	4	2
60-71 lbs	9-10 yrs		2 1/2 (TSP)	5	2-1/2
72-95 lbs	11 yrs		3 (TSP)	6	3
96 lbs & over	12 yrs				4

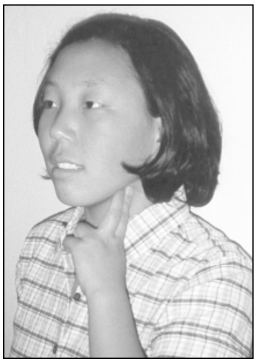
Use only as directed.
NOTE: If possible, use weight to dose; otherwise use age. To arrive at the correct dose, weigh your child before giving TYLENOL®. All dosages may be repeated every 4 hours, but not more than 5 times daily. A health care professional should be consulted for dosing for children under the age of two years.
WARNINGS:
- Children's TYLENOL® should not be taken for pain for more than 5 days or for fever for more than 3 days unless directed by a physician. If pain or fever persists or gets worse, if new symptoms occur, or if redness or swelling is present, a physician should be consulted because these could be signs of a serious condition.
- Do not exceed recommended dose. Taking more than the recommended dose (overdose) may not provide more relief and could cause serious health problems. Keep this and all drugs out of the reach of children. In case of accidental overdose, contact a physician or poison control center immediately. Prompt medical attention is critical even if you do not notice any signs or symptoms.
- **Do not use with any other product containing acetaminophen.**
- Do not use Adult Extra Strength TYLENOL® products for children under 12 years of age.

Courtesy of Children's TYLENOL a product of McNeil Consumer Healthcare

ACTIVITY 3: THE CHEMICAL CAFFEINE: HOW DO YOU RESPOND?

Note: Before beginning this investigation, be sure to have a signed permission letter from parents or guardians for the students to ingest a caffeinated soft drink (use Master 4.4, *Parent Letter*). Those students for whom you do not have permission can participate in the investigation by drinking water; they will provide a control for the activity.

1. **Because their heart rates might be elevated from their walk to class, spend several minutes allowing students to rest and talk quietly. Find out what students know about the chemical caffeine. Use material from the *Background Information* to discuss caffeine briefly. Then, if you have not already done so, teach students how to find their pulse, count their heartbeats, and calculate their resting heart rate.**



You can find your pulse most easily by pressing two fingers against the artery in your neck or on the inside of your wrist. It is easiest to count beats for only 15 seconds and then multiply the number you count by four to find your resting heart rate for one minute. Repeat the counting several times until most students have calculated a resting heart rate that is close to the same number several times in a row. Alternatively, you can have partners verify each other's heart rate.

2. **Distribute Master 4.5, *The Chemical Caffeine: How Do You Respond?*, one to each student. On your signal, ask students to measure their heartbeats one more time for 15 seconds, stopping when you call time. Instruct students to calculate their resting heart rate for one minute by multiplying the number they counted by four. Direct them to record it on the data table on the master.**

3. **Ask students to work in pairs. Distribute the cans of the same kind of caffeinated soft drink, one to each student. Instruct students to follow the directions on the master. Remind them to continue to sit at rest. They can talk to their partner but should keep their bodies still so that they do not elevate their heart rate with activity.**

Tip from the field test: Assign some reading to students from which they can take a break periodically to measure their heart rate. Planning ahead for quiet activity helps keep the students focused on the task.

Content Standard A: Students should develop abilities necessary to do scientific inquiry and understandings about scientific inquiry.

4. When all the students have filled in their data tables and calculated the difference between their resting heart rate and the highest heart rate after ingesting a caffeinated soft drink, discuss their findings by asking questions such as these:

- **Did your heart rate go up, down, or stay the same after you drank a caffeinated soft drink?**

On average, most students should have seen their heart rate go up after drinking the caffeinated soft drink. Some sample data from a field-test class looked like this:

Measurements of Heart Rate at Rest and After Caffeine

Male or Female	Resting Heart Rate	Highest Post-Caffeine Heart Rate
F	80	88
M	88	100
M	76	116
M	68	76
M	72	92
M	80	92
F	76	92
F	68	84
F	68	92
F	72	80
M	80	74
M	64	84
F	68	88
F	84	84
M	80	96
M	72	104

- **On the basis of your observations, what generalization can you make about the effect of caffeine on the human body?**

Caffeine appears to increase heart rate.

- **Why was it important that all students drank the same kind and amount of soft drink?**

Students will recognize that the variable they are interested in testing is individual susceptibility to caffeine. They need to keep as many other factors in the investigation constant, such as amount and kind of soft drink (because different soft drinks have different amounts of caffeine), time of day for the investigation, and temperature of the classroom.

- **Did all the members of the class have exactly the same results when they drank a caffeinated soft drink?**

While most members of the class will see their heart rate increase, the amount of increase will vary significantly.

- **Compare your results with those of other members of the class. What is your individual susceptibility to caffeine?**

Ask students to compare how much their heart rates increased after exposure to caffeine. Those whose heart rates increased significantly can draw the conclusion that they are very susceptible to caffeine. Those whose heart rates did not increase very much, or went down, can draw the conclusion that they are less susceptible to caffeine.

- **Why might some people be more individually susceptible to the effects of caffeine than others?**

Students vary from one another in gender, size, frequency of caffeine consumption, metabolic rates, and so on. This variability makes each student react differently to exposure to caffeine.

- **What do the results of your investigation tell you about the possible risks to some people of ingesting the chemical caffeine?**

Although research has shown that caffeine is safe to consume in moderate amounts, doctors suggest that people who have high blood pressure or trouble with irregular heartbeats avoid caffeine.

Extension Activity

Ask students to examine the labels from some product packages for directions for use and warnings. Suggest that students look at a variety of products, such as household cleaners, cold medicines, and vitamins. Instruct students to summarize information about the following for each product:

- **route of exposure**
- **dose**
- **individual susceptibility**

Students' summaries will vary depending on the products they choose. Encourage them to examine at least one product that is meant for human ingestion, such as a medication, because the product label should contain information about dose and individual susceptibility. Remind them that labels from some products, such as household cleaners, will have information about routes of exposure but probably will not include information about dose or individual susceptibility.